

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
5 August 2004 (05.08.2004)

PCT

(10) International Publication Number  
**WO 2004/065926 A1**

(51) International Patent Classification<sup>7</sup>: **G01L 1/22**  
(21) International Application Number:  
PCT/US2004/001708

(22) International Filing Date: 23 January 2004 (23.01.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
60/442,134 23 January 2003 (23.01.2003) US

(71) Applicant (for all designated States except US):  
**WILLIAM MARSH RICE UNIVERSITY** [US/US];  
6100 Main Street, Houston, TX 77843 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **BARRERA, Enrique, V.** [US/US]; 916 South Shepard, Houston, TX 77019 (US). **NAGARAJAIAH, Satish** [IN/US]; 3106 Pablo Picasso Drive, Sugar Land, TX 77479 (US). **DHARAP, Prasad** [IN/US]; 4100 Greenbriar, No. 318, Houston, TX 77098 (US). **ZHILING, Li** [CN/US]; 4045 Linkwood, No. 335, Houston, Tx 77025 (US). **KIM, Jongdae** [US/US]; 5740 Gulfon, No. 1367, Houston, TX 77081 (US).

(74) Agent: **SHADDOX, Robert, C.**; Winstead Sechrest & Minick P.C., P.O. Box 50784, Houston, TX 75201 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

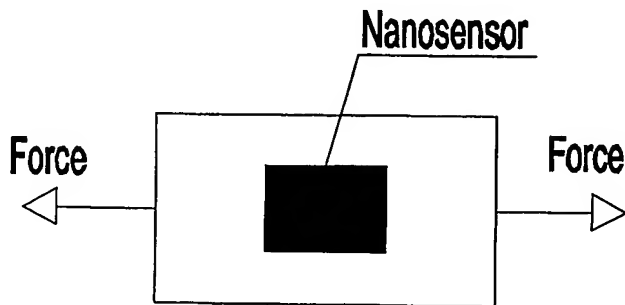
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published:**

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: SMART MATERIALS: STRAIN SENSING AND STRESS DETERMINATION BY MEANS OF NANOTUBE SENSING SYSTEMS, COMPOSITES, AND DEVICES



(57) **Abstract:** The present invention is directed toward devices comprising carbon nanotubes that are capable of detecting displacement, impact, stress, and/or strain in materials, methods of making such devices, methods for sensing/detecting/monitoring displacement, impact, stress, and/or strain via carbon nanotubes, and various applications for such methods and devices. The devices and methods of the present invention all rely on mechanically-induced electronic perturbations within the carbon nanotubes to detect and quantify such stress/strain. Such detection and quantification can rely on techniques which include, but are not limited to, electrical conductivity/conductance and/or resistivity/resistance detection/measurements, thermal conductivity detection/measurements, electroluminescence

detection/measurements, photoluminescence detection/measurements, and combinations thereof. All such techniques rely on an understanding of how such properties change in response to mechanical stress and/or strain.

WO 2004/065926 A1